

CANYONLANDS NATIONAL PARK RESEARCH SUMMARY 2008

1) Study Title: Colorado River Tamarisk Biological Control Monitoring Project:
Loma, Colorado to Lake Powell

Permit No.: CANY-2008-SCI-0001

Principal Investigator: Lindsey Clark Tate

Purpose of Scientific Study: The purpose of this study is to support a body of knowledge to determine the value of the tamarisk leaf beetle, *Diorhabda elongata*, as a tamarisk biocontrol agent, on the Colorado River from Loma, CO to Lake Powell, UT. The four goals of this study are to obtain data concerning the dispersal and establishment of *D. elongata*, measure the efficacy of the beetle in controlling tamarisk, monitor the safety of biological control, and to ascertain the impact of biocontrol on riparian ecology.

The overall impact of *D. elongata* on western ecology is not well understood. Among factors most critical to tamarisk biocontrol success is the ability to predict and control beetle dispersal and establishment. Tamarisk mortality in cage tests was achieved following three sequential seasons of defoliation. Initial field studies indicate that more seasons of defoliation may be required to achieve tamarisk die off. In some instances beetles avoided plants that had been defoliated the year before, affording the tamarisk a recovery period and decreasing chances for mortality (Dudley and DeLoach 2004). Thus, ensuring beetle population longevity in any one area is essential to successful tamarisk control.

Data collection will provide information to support the three major long-term research objectives shown below with their correlating short-term objectives:

- (1) To obtain data that will aid in the future prediction and control of *D. elongata* dispersal and establishment. Gathering such data is invaluable to predict patterns and rates of eventual tamarisk mortality rates. Thus, the first immediate objective is to: (a) track largescale dispersal patterns of *D. elongata*.
- (2) To measure the efficacy of *D. elongata*, in the control of tamarisk. Efficacy data will provide critical information to biocontrol viability. Therefore, the second immediate objective is to: (b) measure tree stress by recording changes in tree morphology (i.e. defoliation).
- (3) To ascertain the safety of *D. elongata* as a biological control agent. The possibility of biocontrol agents switching hosts is a concern. Although there are no recorded host-plant switches in weed biocontrol it is prudent to note any feeding, damage, beetle development, or population suppression of non-target plant populations. For this reason one objective will be to: (c) routinely survey non-target plants for the presence of *D. elongata*. Beetles have been found on other plants but in no instance have they persisted or impacted plants other than tamarisk.
- (4) To study the impact of *D. elongata* on riparian ecology. To date data shows an increase in other non-native plants (kochia, Russian knapweed and perennial pepperweed) in tamarisk defoliation areas. This information was gathered at sites (Lovelock, NV and Pueblo, CO) with little opportunity for other vegetation to establish. Thus, another objective is to: (d) collect a larger database of vegetative response to tamarisk defoliation.

These objectives represent research needs identified by several consortia of scientists and practitioners such as the Saltcedar Biological Control Consortium of Texas, New Mexico, and Mexico and participants in the Tamarisk Research Conference held in Ft. Collins, CO in October of 2006. The results of these western Colorado research objectives will inform ongoing research analyzing *D. elongata*.

Findings/Accomplishments for 2008: *D. elongata*, tamarisk defoliation, and vegetation data were recorded every 1.5 kilometers on the Colorado River from Loma, CO to Lake Powell, UT July 5th to the 18th, 2008. River miles discussed below are those found in Belknap's Waterproof Canyonlands River Guide.

Adult *D. elongata* were found consistently along 235.5 kilometers, beginning near Westwater Canyon at river mile 123.8 and ending at 193 (about 20 miles upstream of Lake Powell). Two additional beetle locations were documented just downstream of Loma, CO at river miles 143.5 and 134.5.

2) Study Title: Assessment of Upland Ecosystem Conditions in the Salt Creek Watershed, Canyonlands National Park

Permit No.: CANY-2008-SCI-0002

Principal Investigator: Mark Miller

Purpose of Scientific Study: This project involves the assessment of upland ecosystem conditions (soil stability, hydrologic function, and vegetation composition/structure) in the Salt Creek watershed and surrounding portions of Canyonlands National Park (CNP).

Findings/Accomplishments for 2008: The purpose of this project is to assess the condition of upland ecosystems in the Salt Creek watershed and surrounding portions of Canyonlands National Park (CNP) using a suite of quantitative and qualitative indicators related to the functioning of key ecosystem processes. Salt Creek is the only perennial stream in CNP other than the Colorado River itself, and riparian and aquatic ecosystems associated with the Salt Creek drainage may be affected by upland watershed conditions impacted by past land-use practices (e.g., livestock grazing), recent / current visitor-use activities, or on-going drought. During the 2006 field season, approximately 100 assessments were conducted in the lower, middle, and upper Salt Creek watersheds. In 2007, 50 assessments were conducted in lower, middle, and upper Salt Creek; as well as in Elephant Canyon, Butler Wash, Lavender Canyon, and Davis Canyon watersheds. Field work for this project was completed in 2008, with 14 assessments conducted in CNP in conjunction with a companion project funded by The Nature Conservancy (TNC). This TNC project was initiated on Bureau of Land Management (BLM) lands adjacent to CNP in 2007, with approximately 200 assessments conducted on BLM land during the 2007 and 2008 field seasons. Both projects used identical sampling strategies and field methods, and combined analysis of both data sets will greatly improve our capacity to understand patterns of ecosystem condition in relation to past and on-going land-use activities, climate, and soil properties. For example, preliminary analyses suggest that soil stability and ground cover both tend to be higher on NPS lands in CNP than on BLM lands. Emerging patterns also suggest that particular soils and types of ecosystems are highly susceptible to long-term dominance by invasive exotic plants. Results of this project will allow NPS staff to evaluate current conditions in relation to management objectives and "desired future conditions," as well as to establish priorities for restoration or other management actions. Data collected on NPS lands will help BLM managers better understand the condition of lands they manage, and data for both companion projects will be used by the NPS Inventory and Monitoring Program, the USDA Natural Resources Conservation Service, TNC, and USGS to better understand ranges of variability in indicators of ecosystem condition and to develop hypotheses concerning the resistance and resilience of particular soils / ecological sites to interactive effects of climate and land-use activities. A combined final report for both projects will be completed and delivered to NPS, TNC, and BLM in 2009.

3) Study Title: Exhumation history of the central Colorado Plateau in the Monument Uplift to Book Cliffs Region, Utah

Permit No.: CANY-2008-SCI-0003

Principal Investigator: Markella Hoffman

Purpose of Scientific Study: The timing and mechanisms of surface uplift of the Colorado Plateau to its present elevation of nearly 2 km continue to be a topic of debate among geologists. In particular, the interplay between surface uplift and late Cenozoic erosion remain largely enigmatic. This study investigates the temporal and spatial distribution, magnitude, and rate of erosional exhumation and river incision that has carved the modern landscape of the Colorado Plateau. Apatite (U-Th)/He thermochronometry is used to establish the thermal and erosional history of the central Colorado Plateau in eastern Utah, between Monument Uplift and the Book Cliffs, and reconstruct the geomorphic evolution of this spectacular landscape. Sandstone samples were collected for thermochronometric analyses along vertical surface sample transects in the Book Cliffs and Canyonlands National Park (NP). Since surface samples only allow access to a small window of vertical exposure, thermochronometric analysis of drill cores are also used to more comprehensively quantify the erosional exhumation history of the region.

Findings/Accomplishments for 2008: My research uses apatite (U-Th)/He thermochronometry to quantify the erosional exhumation history of the central Colorado Plateau. We focused on three regions: the Monument Uplift, Canyonlands NP, and the Book Cliffs area of eastern Utah. Fieldwork in Canyonlands National Park began in May 2007. Since a few more rock samples were needed, we conducted another fieldwork season in May 2008. During this trip, seven more sandstone samples were collected for thermochronometric analyses. We collected these samples along Shafer Trail, Lathrop Canyon, and White Rim Road in Canyonlands National Park. Since then, all (U-Th)/He thermochronometric analyses have been completed for this project. Detrital zircon (U-Th)/He ages from the Canyonlands area are generally older than depositional ages and indicate little to no thermal resetting after burial. Since the majority of sample ages were not reset, the samples from Canyonlands were never in the zircon helium partial retention zone (HePRZ) and subsequently, no more than 6 km of sediment overburden was present in the central Colorado Plateau, assuming $\sim 25^\circ\text{C}/\text{km}$. Instead, zircon (U-Th)/He ages $\sim 250\text{--}650$ Ma likely record the age of crystallization rather than cooling associated with the exhumation of the Colorado Plateau. On the other hand, detrital apatite (U-Th)/He ages from sandstone samples and cores are significantly younger than depositional ages, suggesting complete or partial thermal resetting after sediment transport and burial. Our three areas of focus, Monument Uplift, Canyonlands, and the Book Cliffs, yield similar results. Deep core samples (depths >1000 m) from these areas indicate significant late Miocene to Pliocene cooling and exhumation $\sim 3\text{--}8$ Ma. Shallower cores and surface samples have a broad spread of Paleocene to late Miocene ages from $\sim 8\text{--}55$ Ma, and show these samples resided in the lower portion of the HePRZ. These apatite (U-Th)/He results indicate the central Colorado Plateau experienced a period of rapid erosional exhumation ~ 6 Ma. Evidence of an exhumed HePRZ at the current surface of the central Colorado Plateau suggests $\sim 1\text{--}3$ km of sediment erosion since the late Miocene to early Pliocene. Increased erosion during this time may be controlled by a variety of driving forces. Rapid removal of large quantities of sediment by the Colorado River could indicate significantly more precipitation and an overall wetter climate in the Pliocene. Drainage integration of the Colorado River with other rivers, such as the Green River, may have increased erosion in the central Colorado Plateau. Colorado River drainage integration off the southwest Colorado Plateau at ~ 6 Ma and the subsequent lowering of base level is thought to have caused most of the incision in the Grand Canyon region and may be responsible for

incision in the Canyonlands area as well. Regional tectonics, such as the opening of the Gulf of California ~5-6 Ma, in combination with Colorado River drainage integration during this same time could play a powerful role in erosion of the central Colorado Plateau in the late Miocene.

4) Study Title: Monitoring the Colorado pikeminnow population in the mainstem Colorado River via periodic population estimates

Permit No.: CANY-2008-SCI-0004

Principal Investigator: Douglas Osmundson

Purpose of Scientific Study: To periodically provide estimates of population size of the Colorado River population of the endangered Colorado pikeminnow. Such estimates were made during 1991-1994, 1998-2000, and 2003-2005. Our field station initiated a new three-year study beginning in 2008. The study area extends from Palisade, Colorado to the confluence with the Green River in Utah (185 miles). The lower 40 miles of the study area is within Canyonlands National Park.

Findings/Accomplishments for 2008: In this first year of the fourth effort, four complete passes were made through the upper and lower reaches of the Colorado River study area (12-mile-long Westwater Canyon, separating the two reaches, was not sampled) using a combination of electrofishing and backwater trammel-netting. Crews had just enough time to squeeze in an extra, or fifth, pass through the upper reach. Sampling was conducted from April 3 through June 19. Although the field effort went very well, the number of Colorado pikeminnow captured was fairly low relative to previous years. In the upper reach, there was a mean of 17 fish captured per pass (total of 85) compared to 14 in 2003, 20 in 2004, and 31 in 2005. In the lower reach, there was a mean of 26 fish captured per pass (total of 102) compared to 28 in 2003, 30 in 2004, and 39 in 2005. The number of fish marked in the first passes that were subsequently recaptured in later passes was low compared to previous years, especially in the upper reach: there, only four within-year recaptures were made compared to three in 2003, 10 in 2004, and 22 in 2005. In the lower reach, the within-year recapture rate was somewhat better: there were eight in 2008 compared to two in 2003, three in 2004, and 27 in 2005. In 2008, the duration of spring runoff was especially long and made for good electrofishing and backwater netting conditions. A total of 41 boat-days was expended on trammel-netting compared to 37 in 2003, three in 2004, and 41 in 2005. So lack of backwaters cannot account for capture rates being lower than in 2005. The total number of pikeminnow captured in 2005 was 319 (four passes in upper reach; five passes in lower reach) compared to 187 in 2008 (five passes in upper reach; four passes in lower reach), or 71% higher than in 2008 (total captures in 2008 was 41% lower than in 2005). Data were entered into Excel but are only now being checked for errors. Hence, no preliminary estimates of population abundance or other vital rates are available yet.

5) Study Title: Testing hypotheses for the origin of Upheaval Dome, Canyonlands National Park, Utah, using deformation bands

Permit No.: CANY-2008-SCI-0005

Principal Investigator: Chris Okubo

Purpose of Scientific Study: This proposal presents work that is a continuation of a previous NPS study (Study # CANY-00095, âTesting hypotheses for the origin of Upheaval Dome, Canyonlands National Park, Utah, using deformation bands.â). This permit renewal is necessary because the work anticipated for the previous permit was not conducted due to a lack of time on the PI's part last year. The PI anticipates sufficient time will be available for these proposed activities in the next year. This work focuses on quantifying geologic evidence that supports a meteoritic

impact origin for Upheaval Dome. The previous study found that the style of faulting within the Wingate Sandstone is indicative of a meteoritic impact, and supports a post-Early Jurassic age for this impact. These results have been published in the journal Earth and Planetary Science Letters. The work proposed here builds upon these previous results and will quantify the distribution and microstructure of cataclastic dikes of Wingate Sandstone at Upheaval Dome. This work will evaluate the validity these cataclastic dikes as an additional line of evidence that supports an impact event at Upheaval Dome.

Findings/Accomplishments for 2008: No activity was conducted this report year.

6) Study Title: Monitoring Protocols to Support Long-Term Monitoring of Aquatic Macroinvertebrates in National Park Service Units of the Northern Colorado Plateau Network

Permit No.: CANY-2008-SCI-0007

Principal Investigator: Anne Brasher

Purpose of Scientific Study: National Park Service units of the NCPN have a need for long-term monitoring of aquatic macroinvertebrates and riparian habitats. Monitoring the condition of aquatic ecosystems, including intermittent and perennial streams, springs, seeps, tinajas, and hanging gardens, is a high-priority need because of the great significance of these resources to parks and because of their sensitivity to a wide range of human impacts. The need for monitoring protocols is particularly urgent due to the ubiquity of factors potentially impacting aquatic systems, including flow diversion, flow regulation, water pollution, alteration to riparian habitat, up-stream development pressures, upland / upstream land-use activities, and water-rights issues.

The National Park Service (NPS) Northern Colorado Plateau Network is developing long-term monitoring programs for aquatic ecosystems (streams, springs, seeps, tinajas, and hanging gardens). This study will provide new data in support of this program. Results will assist the National Park Service to manage water resources in Canyonlands National Park.

Findings/Accomplishments for 2008: No activity was conducted this report year.

7) Study Title: Soil Survey of Canyonlands National Park, Utah

Permit No.: CANY-2008-SCI-0008

Principal Investigator: Victor Parslow

Purpose of Scientific Study: To provide an updated soil and ecological site inventory for Canyonlands National Park (CANY), that meets National Cooperative Soil Survey (NCSS) standards and park management and planning needs. The existing soil survey was conducted in the 1970s and the early 1980s as part of the Henry Mountains, Utah soil survey and the Canyonlands soil Survey. These inventories was primarily designed as a tool for use in managing grazing lands and has been found to be too general to be useful in managing the park. Information is insufficient to model salt movement, mitigate visitor impacts, identify and protect habitat of Threatened and Endangered species, and other park responsibilities.

Findings/Accomplishments for 2008: 1. Soil inventory activities: Soil survey activities were conducted in Canyonlands National Park in 2008. Traverses and transects of the landscape were conducted, and soil descriptions and plant inventory data recorded, in order to further develop the soil-plant-landscape-geology models which will be essential to the completion of the update of the Soil Survey and Ecological Site Descriptions. 634 soil/landscape observations were documented in FY 2008, and soil samples were collected from 92 of these locations. These samples have been catalogued, and are stored in the Richfield USDA Service Center.

2. Archaeological activities: As a result of the field work of 2008, 30 archaeological sites as well as eight isolated occurrences were recorded in Canyonlands National Park. Cultural material was collected from six sites and four isolated occurrences. Another two sites and three isolated occurrences were recorded in the Orange Cliffs section of Glen Canyon Recreational Area with cultural material collected from one isolated occurrence. Details of these resources including locations and descriptions of their contents can be referenced in a more complete report, â Summary Report of Cultural Resources Support Provided to the Soil Surveys Of Natural Bridges National Monument, Arches National Park, Canyonlands National Park and Hovenweep National Monument For the Year 2008, at the SEUG office in Moab, Utah. All cultural resources were successfully avoided. No cultural material was unearthed during the course of soil sample collection.

8) Study Title: Annual Forest Land Inventory of Utah

Permit No.: CANY-2008-SCI-0009

Principal Investigator: Renee O'Brien

Purpose of Scientific Study: The Interior West Forest Inventory and Analysis program is responsible for statewide inventories in eight states. The purpose of this ongoing inventory is to gather information on condition and trends of forest resources to assess plant diversity; fuels and potential fire hazards; condition of wildlife habitats; mortality and risk associated with fire, insects, or disease; and biomass, carbon storage, forest health and other general characteristics of forest ecosystems. Under the annualized inventory system, each field plot is visited one every 10 years, with approximately 10 percent of the total plots visited each year within a state. The FIA program produces a fiveyear report for each State.

Findings/Accomplishments for 2008: As part of the Annual Forest Land Inventory of Utah, field crews visited five plots at Canyonlands NP during the 2008 field season. The results of this ongoing inventory are periodically updated and made available at www.fs.fed.us/rm/ogden. The five-year report for the Utah inventory will be released in 2009. Site-specific summaries of field data will be sent to our NPS contact person at this unit.

9) Study Title: The Role of Biological Soil Crusts in soil nutrient cycles as Influenced by Soil Surface Disturbance, Climate Change and Annual Grass Invasion

Permit No.: CANY-2008-SCI-0010

Principal Investigator: Jayne Belnap

Purpose of Scientific Study: This project will establish how alterations in species composition by surface disturbance, invasive grasses, and/or climate change may affect N and C inputs and fluxes, in different soils under different climatic regimes

Findings/Accomplishments for 2008: We continue to maintain and monitor our long-term research plots, but have no new analyses to report at this time.

10) Study Title: Impacts of Climatic Change and Land Use on the Southwestern U.S.

Permit No.: CANY-2008-SCI-0011

Principal Investigator: Jayne Belnap

Purpose of Scientific Study: The population of the southwestern United States has grown rapidly over the past two decades and is projected to increase greatly over the next several decades. As the population has grown, climatic variations that would have affected relatively few people in the past will impact the lives of millions. Rapid and wide-spread climatic changes, such as those seen thousands and hundreds of years ago in the region and those projected for the future, may profoundly change the character of the region. Arid and semi-arid regions of the southwestern U.S. are

among the most sensitive regions to changes in climate and land use, but the potential interactions between climatic change and land use are largely unknown (http://climweb.cr.usgs.gov/info/sw_new/swmap.html).

U.S. Geological Survey and collaborating scientists are seeking to understand how climate and how land use have influenced surficial geologic processes that modify landscapes and ecosystems. Such understanding is then used to model the landscape's response to future changes in climate and land use over time scales of seasons, of a few years, and of a few decades, so that information and interpretations can be applied by federal, state, and local agencies, as well as by Native American governments, for their land-use planning and management of resources. Project scientists work with ecologists, hydrologists, geographers, cartographers, and archeologists to address questions about:

- (1) the causes and timing of changes in alluvial environments (rivers, streams, hillslopes), such as flooding, the cutting and filling of arroyos, and sediment discharge;
- (2) the role of eolian dust for soil fertility, invasion of exotic species, hydrology, and surface stability in deserts;
- (3) the interaction of physical and biologic processes critical for ecosystem functions;
- (4) how climate in the southwest has varied over decades, centuries, and millennia;
- (5) how future climatic variations will affect the Southwestern land surface (in terms of erosion, sand-dune activity, dust-storm frequency, flooding, landslides,);
- (6) how past climatic changes and environments affected prehistoric cultures.

Specific goals for Canyonlands work

- Understand geologic origins of soil nutrients and the interactions of soil compounds and plants.

- Understand geomorphic controls on plant distribution

- Understand the recent (past several decades, centuries, millennia)

geologic/geomorphic evolution of the ecosystem to reveal patterns of surface stability and instability.

- Recognize areas vulnerable to wind erosion and soil loss.

- Understand conditions of cheatgrass (and other exotic plants) invasion to predict areas most vulnerable to expansion and to help devise mitigation strategies.

Findings/Accomplishments for 2008: Large sediment fluxes can have significant impacts on ecosystems. We measured incoming and outgoing sediment across a gradient of soil disturbance (livestock grazing, plowing) and annual plant invasion for nine years. Our sites included two currently ungrazed sites: one never grazed by livestock and dominated by perennial grasses/well-developed biocrusts and one not grazed since 1974 and dominated by annual weeds with little biocrust. We used two currently grazed sites: one dominated by annual weeds and the other dominated by perennial plants, both with little biocrusts. Precipitation was highly variable, with years of average, above-average, and extremely low precipitation. During years with average and above-average precipitation, the disturbed sites consistently produced 2.8 times more sediment than the currently undisturbed sites. The never grazed site always produced the least sediment of all the sites. During the drought years, we observed a 5600-fold increase in sediment production from the most disturbed site (dominated by annual grasses, plowed about 50 years previously and currently grazed by livestock) relative to the never grazed site dominated by perennial grasses and well-developed biocrusts, indicating a non-linear, synergistic response to increasing disturbance types and levels. Comparing sediment losses among sites, biocrusts were most important in predicting site stability, followed by perennial plant cover. Incoming sediment was similar among the sites, and while inputs were up to 9-fold higher during the drought year at the most heavily disturbed site compared to

average years, the change during drought conditions was small relative to the large change seen in sediment inputs.

11) Study Title: NCPN Integrated Upland Monitoring in Canyonlands National Park
Permit No.: CANY-2008-SCI-0012

Principal Investigator: Rebecca Weissinger

Purpose of Scientific Study: The Northern Colorado Plateau Inventory and Monitoring Network (NCPN) of the National Park Service has identified upland ecosystem characteristics, processes, vegetation, and other biota as vital signs to be monitored. Upland monitoring is intended to strike a balance between increasing fundamental understanding of dryland systems and providing managers early warning of undesirable change. It will document the variability in these systems while providing information needed for resource management decisions. Addressing these two goals will be accomplished partly through sampling design and data analysis. Some sites may be selected as representative of large portions of the landscape, others because of their management history. Evaluation of upland monitoring data in relation to other vital signs will facilitate identification of drivers and distinguishing natural from anthropogenic change. Additionally, plot data from this effort will be used in the classification and interpretation of remotely sensed data.

NCPN upland monitoring objectives for selected ecological sites:

1. Determine annual status and trends in ground cover (live and standing dead vegetation, litter, rock, biological soil crust, and bare ground); spatial pattern of vegetation by life form; soil aggregate stability and compaction as indicators of soil/site stability; hydrologic function, and nutrient cycling.
2. Determine annual status and trends in cover of biological soil crusts by species or morphological group.
3. Determine annual status and trends in cover of exotic plants in upland areas.

To better evaluate monitoring methods and objectives, the NCPN implemented a three year pilot study at CANY.

Findings/Accomplishments for 2008: NCPN completed the final year of a three year pilot study for integrated upland monitoring at CANY. Forty plots were revisited in FY08. An analysis of the three years of data and a sampling design for full implementation of long-term monitoring of upland ecosystems at CANY will be completed in FY09. Sampling will continue based upon the full study design in FY09.

12) Study Title: Plant community response to tamarisk invasion and hydrologic regime in the Cataract Canyon, Canyonlands National Park

Permit No.: CANY-2008-SCI-0013

Principal Investigator: Peter Weisberg

Purpose of Scientific Study: In the past century, changes in hydrologic regimes caused by climate change and river regulation have affected the composition and abundance of riparian woody plants. Many of these species such as cottonwood and Goodding's willow have life history characteristics that are strongly tied to flow regimes, and alterations in hydrologic regimes can inhibit establishment and change successional trajectories. At the same time the invasion of non-native plants such as tamarisk, Russian olive, Russian knapweed, and all whitetop has changed the competitive dynamics of riparian communities. Invasive plants can outcompete native species and alter environmental characteristics such that riparian habitat is no longer suitable for natives. However, the long-term effects of changes in hydrologic

regimes and invasions of non-native species on riparian ecosystems remain uncertain.

This project was designed to assess the long-term vegetation dynamics of riparian communities in Canyonlands National Park (CNP) along the Green and Colorado Rivers. We focused on tamarisk because this species has been spreading through riparian habitat in CNP since 1925 and has become the most abundant riparian woody plant in CNP. Recent releases of the saltcedar leaf beetle along the Green and Colorado Rivers have initiated cycles of tamarisk defoliation and may eventually result in the mortality of large tamarisk stands. Collectively, the information gleaned from this research should provide the Park with spatially-explicit baseline data to measure the effects of the imminent arrival of the saltcedar leaf beetle.

We compared current vegetation composition of the Green, Colorado, and Cataract Canyon rivers. We also conducted an aerial photo analysis of historical changes in woody vegetation (establishment, growth, and mortality of riparian plant community types). This involved mapping vegetation at fourteen large sites and estimating the percent cover of riparian woody species in vegetation patches. A series of historical aerial photos (1976, 1995, 2002) of these sites was acquired from the National Park Service. We measured the aerial cover of riparian vegetation patches in these years and compared the measurements with current (2008) cover. Changes in relative patch composition within sites were compared among the three river corridors through time. We also related changes in patch size of plant species to hydrologic and precipitation records. We further explored the relationships between understory species and overstory woody species in riparian habitat of CNP using a combination of similarity coefficient analyses and logistic regression models to explore potential relationships between understory composition and elevation above the river channel, overstory cover, and the height of dominant overstory species.

We explored the effects of river regulation on vegetation by comparing seedling establishment patterns in slightly regulated (Colorado above confluence), moderately regulated (Green) and extremely regulated (Colorado below Glen Canyon Dam). We conducted 80 random seedling surveys to investigate current germination patterns of tamarisk and other common woody species (coyote willow, Fremont cottonwood, and Goodding's willow). We searched for seedlings in the riparian zone and collected soils from specific sites where seedlings were present. We used logistic regression models to assess presence and absence of tamarisk and coyote willow in relation to soil characteristics (soil texture, conductivity, pH, and nitrogen). With knowledge of the conditions that favor seed germination and establishment, managers should be able to target locations for removal of non-native seedlings and, perhaps, implement restoration of native vegetation in appropriate sites following repeated tamarisk defoliation by the tamarisk leaf beetle.

Findings/Accomplishments for 2008: We conducted a research river trip in three river sections in CNP (Colorado, Green, Cataract Canyon) during October, 2008 to address the current distribution and abundance of woody species, historic vegetation dynamics, characteristics of current germination sites, and associations among understory and overstory plants. Tamarisk dominated the overstory vegetation in all river sections (Green = 86%, Cataract = 83%) but was less dominant along the Colorado (73%). Damage caused by the tamarisk leaf beetle was observed in a patchy distribution along all river sections but was most evident along the Green River. We observed defoliated tamarisk as far downstream as Rapid 12. The majority of tamarisk individuals that had been defoliated were growing new leaves.

The aerial extent of riparian vegetation in the fourteen sites sampled increased overall from 1976 to 2008. This increase corresponds with channel narrowing that has been attributed to climate change, river regulation, and tamarisk dominance. In

Cataract Canyon riparian vegetation decreased between 1976 and 1995, probably as a result of scouring floods in 1983-4. The average patch size of hackberry, desert olive, cottonwood, and tamarisk also decreased from 1976 to 1995. Coyote willow and Goodding's willow patches increased during the same period likely due to their flood adaptations. The relative composition of riparian species remained constant. Within this 30-year period little mortality occurred, and, when it did occur, the same community dominants recolonized. Coyote willow increased slightly along the Green River and Cataract Canyon. Cottonwood and coyote willow had the greatest increases in patch size from 1976 to 2008. Tamarisk and willow patches exhibited opposite trends of growth and decline. During periods in which tamarisk patches decreased, Goodding's willow patches increased in size and vice versa. The percent of seedling survey sites that contained coyote willow and tamarisk seedlings did not differ between the Green, Colorado, and Cataract Canyon sections. However, survey sites in the Grand Canyon had significantly fewer coyote willow seedlings. Regression models revealed relationships between tamarisk and coyote willow seedling presence and soil characteristics for sites

13) Study Title: Geologic Evolution of Cataract Canyon, Canyonlands National Park, Utah

Permit No.: CANY-2008-SCI-0014

Principal Investigator: Robert Webb

Purpose of Scientific Study: We propose to use a combination of geophysical techniques, cosmogenic and radiocarbon dating, and repeated surveys to assess the long-term change and evolution of Cataract Canyon and the Colorado River.

Findings/Accomplishments for 2008: No activity was conducted this report year.

14) Study Title: Forecasting Land Surface Phenology in the Upper Colorado River Basin

Permit No.: CANY-2008-SCI-0016

Principal Investigator: Naomi Kisen

Purpose of Scientific Study: This research focuses on the development of a predictive phenological model for rangeland vegetation in the Upper Colorado Basin. It is intended that the resulting model be used as a management tool (by the BLM) to improve rangeland health conditions. Primary data sets are remote spectral imagery and climate data. However, field verification is an important component of this project. The goal of field verification is to capture the ground level spectral signature of spring time vegetation for comparison with the remotely acquired spectra and the modeled vegetation conditions. Thus it is necessary to have access to vegetation where land use practices have not altered growing season plant biomass so as to significantly reduce the spectral reflectance of plant growth.

Findings/Accomplishments for 2008: Spectra of vegetation recorded from different vegetation communities within the park was analyzed and identifying patterns in the spectral profile of the vegetation communities were identified.

15) Study Title: A study of the distribution of *Catocala benjamini* and related *Catocala* in northeastern Arizona and southeastern Utah.

Permit No.: CANY-2008-SCI-0017

Principal Investigator: John Peacock

Purpose of Scientific Study: The name "ute" has been proposed by Peacock and Wagner as a new subspecies of *Catocala benjamini* in eastern Utah (Arches and Canyonlands NP). The purpose of the present study is to collect females of "ute" for ova and to compare the numbers of "ute" in Canyonlands with those found in Arches. Ova from "ute" females will permit the rearing of larvae in 2009. As yet the larva of

this subspecies is undescribed, and if the study is successful, the ova and larva of the subspecies will be described in scientific publications.

Findings/Accomplishments for 2008: In an attempt to further define the range of *Catocala benjamini ute*, fermented fruit-baited traps were deployed in the Squaw Flat CG area of Canyonlands NP on 10 June 2008. Only one *Catocala* (*C. chelidonia*) was found in the traps on 11 June. This adult male was killed and preserved for further study (DNA analyses, etc.)

16) Study Title: Hydrology and geomorphology in Arid River Systems:
A Case Study in Canyonland Country

Permit No.: CANY-2008-SCI-0018

Principal Investigator: Anne Brasher

Purpose of Scientific Study: To study the hydrology and geomorphology of the Salt Creek watershed in the Needles District of Canyonlands National Park. This study seeks to understand linkages among hydrologic, geomorphologic, and riparian characteristics to help predict stream health and stream channel trends in arid river ecosystems. The study will look at natural versus anthropogenic impacts to the stream.

Findings/Accomplishments for 2008: 39 geomorphic cross-sections were surveyed in Salt Creek, CANY. Data analysis, including mapping of cross-sections, is ongoing. Preliminary results, including a site map, will be available at the end of March.

17) Study Title: Atmospheric Dust Deposition to Canyonlands National Park

Permit No.: CANY-2008-SCI-0020

Principal Investigator: Jayne Belnap

Purpose of Scientific Study: The purpose of installing a total suspended particulate (TSP) sampler at Island in the Sky, Canyonlands National Park is to quantify the transport of windblown dust and to characterize the temporal variations in the chemical composition of this dust. Dust is a major atmospheric contaminant and a primary cause of reduced visibility in National Parks and other Class 1 airsheds. Despite the importance of dust to air quality and visibility, the sources, variability and composition of dust is not well understood. Accordingly, we are proposing the installation of a dust collector at Island in the Sky in CNP in order to develop a long-term dataset on dust deposition to the park. There are many factors that control the emission of dust from arid ecosystems including both land-use and climate. However, in order to better assess the quantity of material that is moved as well as its geochemical composition, we need the ability to regularly collect samples of suspended dust. The proposed sampler will provide a tool for the collection and chemical analysis of dust on a regular timescale and will greatly improve our estimates of dust fluxes to and from Canyonlands NP. The TSP sampler is a simple instrument that allows for the high volume filtration of suspended particulates. It consists of a 7.0 amp pump motor that is housed in an aluminum enclosure, resembling a large birdhouse. The pump pulls air over the lip of the aluminum enclosure through an 8" x 10" filter paper. The physical barrier provided by the lip prevents large objects such as leaves or insects from being collected on the filter but does allow the collection of a large range of particle sizes. In comparison with other common aerosol sampling equipment, such as those used by the IMPROVE network, the TSP is able to collect a more representative sample of suspended dust. Additionally, because the TSP rapidly samples high volumes of air, more concentrated samples can be collected. The flux of dust from Canyonland ecosystems has important ecological implications. Dust is generated from the wind erosion of

surface soils and this process is most extreme in arid and semi-arid ecosystems. Both the removal and subsequent deposition of dust can influence the ecosystem nutrient cycling and productivity. For example, the removal and/or redistribution of surface soils in arid ecosystems have been shown to alter the nutrient composition of surface soils and to influence the heterogeneity in vegetation composition.

Additionally, dust exported from the arid southwest can be represent and significant input of materials to downwind ecosystems as far away as the Rocky Mountains

Findings/Accomplishments for 2008: The sampler was installed, and is maintained, and samples collected regularly by NPS personnel.

18) Study Title: Earthscope/USArray Transportable Array Seismic Station

Permit No.: CANY-2008-SCI-0021

Principal Investigator: Robert Busby

Purpose of Scientific Study: The USArray Transportable Array is an Earthquake monitoring system, operated and maintained by IRIS (a non-profit corporation of US universities) on behalf of the National Science Foundation. It uses continuously operating seismic stations to measure ground motion caused by earthquakes and volcanic processes.

Findings/Accomplishments for 2008: This station recorded 940 regional and 1843 distant earthquakes between the time period of 6/16/2007 to the present. (A summary report will be sent directly to the park.)

19) Study Title: Vegetation Data Collection in Support of the U.S. Geological survey – National Park Service Vegetation Classification and Mapping Program at Canyonlands National Park

Permit No.: CANY-2008-SCI-0024

Principal Investigator: Janet Coles

Purpose of Scientific Study: The National Park Service's Inventory and Monitoring Program, Natureserve, and Engineering-Environmental Management, Inc. (E2M) are collaborating in a multi-year project to produce detailed maps of the existing vegetation in Canyonlands National Park.

Findings/Accomplishments for 2008: Draft final vegetation maps were completed for the Needles District (July 2008) and the Maze District (August 2008). NPS GIS staff created a pool of several thousand potential sample sites within these districts using a stratified random design. Field crews visited nearly 1200 of these points between August and November, 2008 to determine their vegetation in a blind test of the map's accuracy. Approximately 150 points remain to be sampled along the Green River and in the Needles District in order to acquire a statistically viable sample of each of the park's 65 map classes. Field data are being entered into an Access database and quality-checked. Determinations of the vegetation made in the field will be compared with map class assignments and an initial estimate of the map's accuracy made. Errors will be analyzed and CANY staff consulted as to the best way to resolve errors in order to raise the thematic accuracy of each map class to at least 80%.

20) Study Title: Population monitoring of humpback and bonytail chub in Cataract Canyon

Permit No.: CANY-2008-SCI-0025

Principal Investigator: Paul Badame

Purpose of Scientific Study: Goals: Maintenance of long term catch rate trend data, longitudinal distributions, and population size structures for humpback and bonytail within Cataract Canyon.

Objectives:

1. Complete one ten day pass each year sampling five sites within Cataract Canyon.
2. Obtain highest possible rates of capture of humpback and bonytail within concentration habitats and maximize number of individuals marked and captured at each sampling site.
3. Determine annual catch rate trend for chubs, examine population size structure, and compare longitudinal distribution to past years.

Findings/Accomplishments for 2008: One eight day sampling trip was completed between October 23 and November 1. Total sampling effort included 409 hours of trammel netting and 6 hours of electrofishing. Total captures for endangered fish included six humpback chub and two razorback suckers. An annual report identifying catch rates and relative annual trends will be submitted to the USFWS in 2010.